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TECHNICAL REPORT 83-5

PERFORMANCE OF LATEX MODIFIED AND HIGH DENSITY CONCRETE OVERLAYS

NOVEMBER 1983

BR 1 (8/83)

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PERFORMANCE OF LATEX MODIFIED AND HIGH DENSITY CONCRETE OVERLAYS

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November 1983

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M.A.P. CODE 7.42-6-83-5

ABSTRACT

This is a performance report of monolithic bridge decks which had been overlaid with Latex Modified or High Density Concrete.

Nine structures which had been overlaid due to reinforcing steel corrosion induced spalling were selected to represent statewide performance. The overlays on these representative structures have been in service from four to seven winters.

Visual, potential and delamination surveys were used to follow performance of the overlaid bridge decks.

Potential surveys show that active corrosion decreased or was eliminated after the overlay was constructed.

A new style beveled construction joint has proven successful. The new style joint replaced the original butt joint which had separated and allowed leakage.

Delamination of the overlay occurred near bridge joints and at shrinkage cracking locations. Delaminations comprise only 0.2% of the areas surveyed.

Performance surveys will be continued to monitor long term performance.

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TABLE OF CONTENTS

	Page
Background	1
Discussion of Location's Performance	
Washington Avenue Over I90, Renssealer County	2
Lake Street Over I684, Westchester County	4
Route 20 Over 18 Mile Creek, Erie County	6
North Genessee Street Over Mohawk River Barge Canal, Oneida County	8
North Genessee Street Over Reall Creek, Oneida County	10
Route 378 Eastbound Over Broadway, Albany County	12
Horton Viaduct On Route 17, Delaware County	14
Route 15 Southbound Over Conrail, Steuben County	16
Route 222 Over Fall Creek, Tompkins County	18
Conclusions	21

BACKGROUND

This report was written to summarize the information on performance of High Density and Latex Modified Concrete bridge deck overlays. Since chloride contaminated concrete had been left in place, the overlays were constructed as Experimental Cost Effective Reconstruction Techniques in accordance with Federal Highway Administration procedures.

Nine structures were selected for future evaluations. The first placements of each type of overlay were selected along with additional placements to balance the types being evaluated. Representative spans of some long structures were selected to make testing and evaluations practical. The areas of each type of overlay being evaluated are 26,648 square feet of Latex Modified Concrete and 25,257 square feet of High Density Concrete.

Post construction surveys of the completed overlays consisted of visual observations, potential surveys (to detect active corrosion of the reinforcing steel using a Cu-CuSO4 half cell) and delamination surveys. It was planned to conduct these surveys at two year intervals after construction. However, personnel changes and other work have extended this time interval in some cases. Future evaluations will be scheduled at the two year or more frequent intervals if conditions dictate. No new overlay locations of these types will be added to this project as the most value to be gained is by observing the performance of the oldest deck overlays.

DISCUSSION OF EACH LOCATION'S PERFORMANCE

The following discussions of each overlay location were written based on surveys before and after construction.

The histograms of Potential percentage equal to or greater than 0.35 volts versus year surveyed were chosen to show any changes in active corrosion of the reinforcing steel with time. Research work performed by FHWA and others shows that when a Cu-CuSO4 half cell potential reading equals or exceeds 0.35 volts active corrosion is present. However, this does not indicate the amount of corrosion present only whether active corrosion is taking place. Visual observations and delamination surveys are necessary to tell when enough corrosion product has been built up to cause expansive forces leading to delamination and spalling of the concrete.

Additional information, consisting of the number(n) average(avg.) and standard deviation (S.D.) of all the potential readings for each survey year, is also included.

WASHINGTON AVENUE OVER I90, RENSSELAER COUNTY, REGION 1
CONTRACT D95204, BIN 1092600, TWO SPANS

Total deck area of 6,400 square feet is being evaluated.

This structure was overlaid with High Density Concrete in 1976 and 1977. In the Fall of 1976, the overlay was placed on the north side lane of the deck while traffic was maintained on the remaining lane. Cold weather caused construction to halt until the Spring of 1977 when the remaining lane was completed.

Potential, delamination and visual surveys were conducted before and at intervals after construction. Results of the potential surveys are presented in Figure 1.

Figure 1 shows the initial high percentage of active corrosion before construction and the low percentage of active corrosion after construction of the overlay in 1977. In 1978 active corrosion increased in span 1 and 2 adjacent to the longitudinal construction joint between overlay placements. This butt joint had separated and moisture, oxygen and deicing chemicals had penetrated causing active corrosion to occur. The potential survey in 1978 also showed a general area of active corrosion in one lane. This is partially explained by the presence of radial cracking eminating from core holes. Cores had been taken to determine bond strength. It appears that cracking was due to normal shrinkage which initiated at the core hole when the coring broke the uniformity of the overlay. Though the core holes had been patched, moisture, oxygen and deicing chemicals did penetrate to cause active corrosion. Some areas around core holes had delaminated.

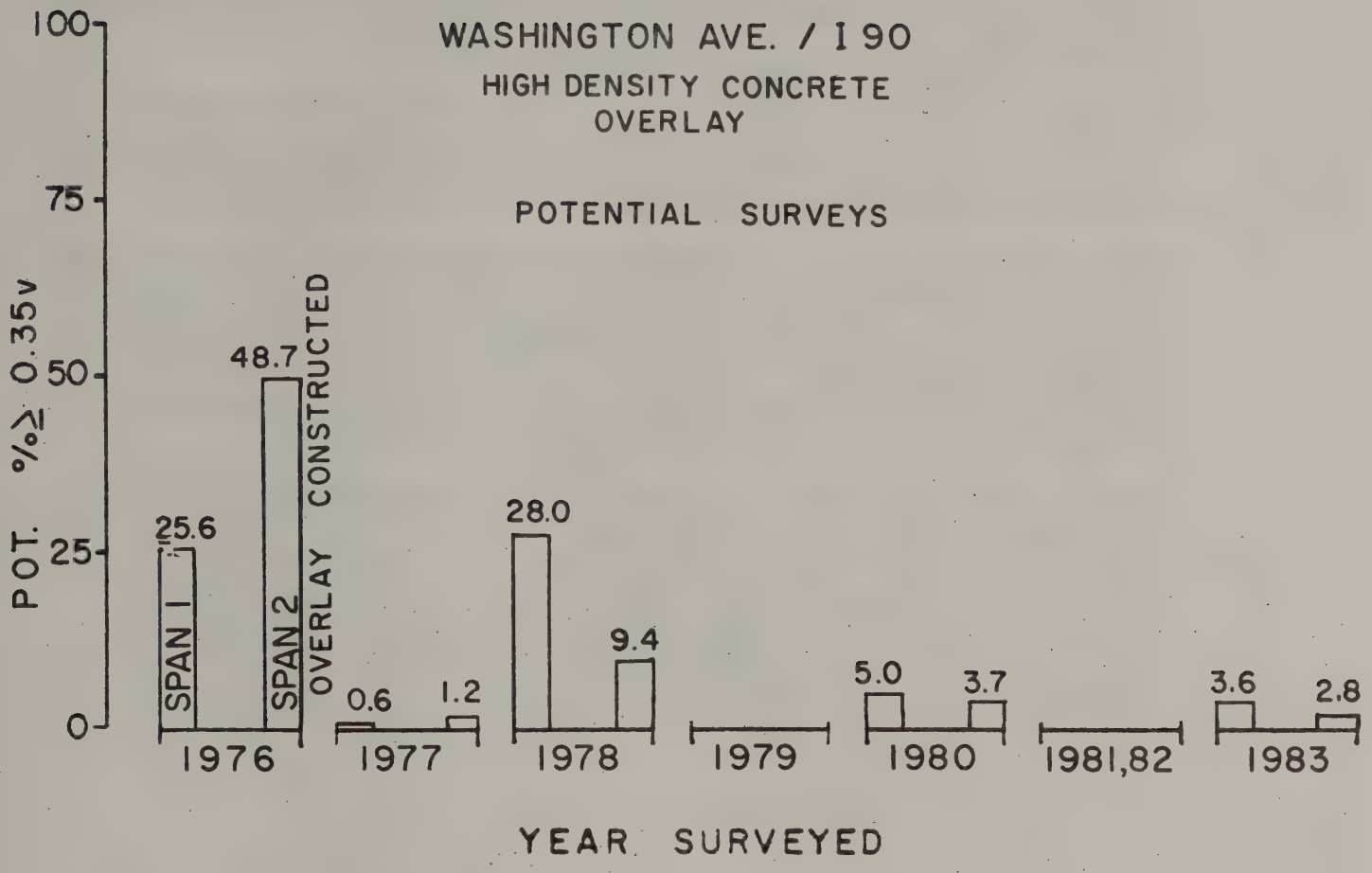
Maintenance forces corrected the minor spalling at the core hole and the delamination by chipping out the delaminated area and using a quick setting concrete repair material.

Narrow width transverse cracking was also present in this overlay and potential readings indicating active corrosion were associated with them. No hollow sounding delaminated areas were found in the vicinity of the transverse cracks or at the separated longitudinal joint.

In 1980, active corrosion had become very low and survey data showed active corrosion had occurred at some patched areas (not all radial cracks were removed). Active corrosion was also occurring in some areas at the longitudinal construction joint.

In 1983, active corrosion continued to be very low, and was associated with cracks. No delaminations were found in the overlay. However, three out of the four patched core holes had delaminated. One of these had spalled due a thin edge of the patch material.

FIGURE 1



		1976,7	1977	1978	1979	1980	1983
Span 1	n	156	161	161	N	161	139
	avg.	.27	.21	.30	O	.24	.24
	S.D.	.10	.06	.07	S	.06	.06
					U		
Span 2	n	158	162	160	R	162	141
	avg.	.34	.19	.27	V	.22	.21
	S.D.	.11	.06	.05	E	.06	.05
					Y		

LAKE STREET OVER I684, WESTCHESTER COUNTY, REGION 8
CONTRACT D95196, BIN 1052950, FOUR SPANS

Total deck area 8,624 square feet is being evaluated.

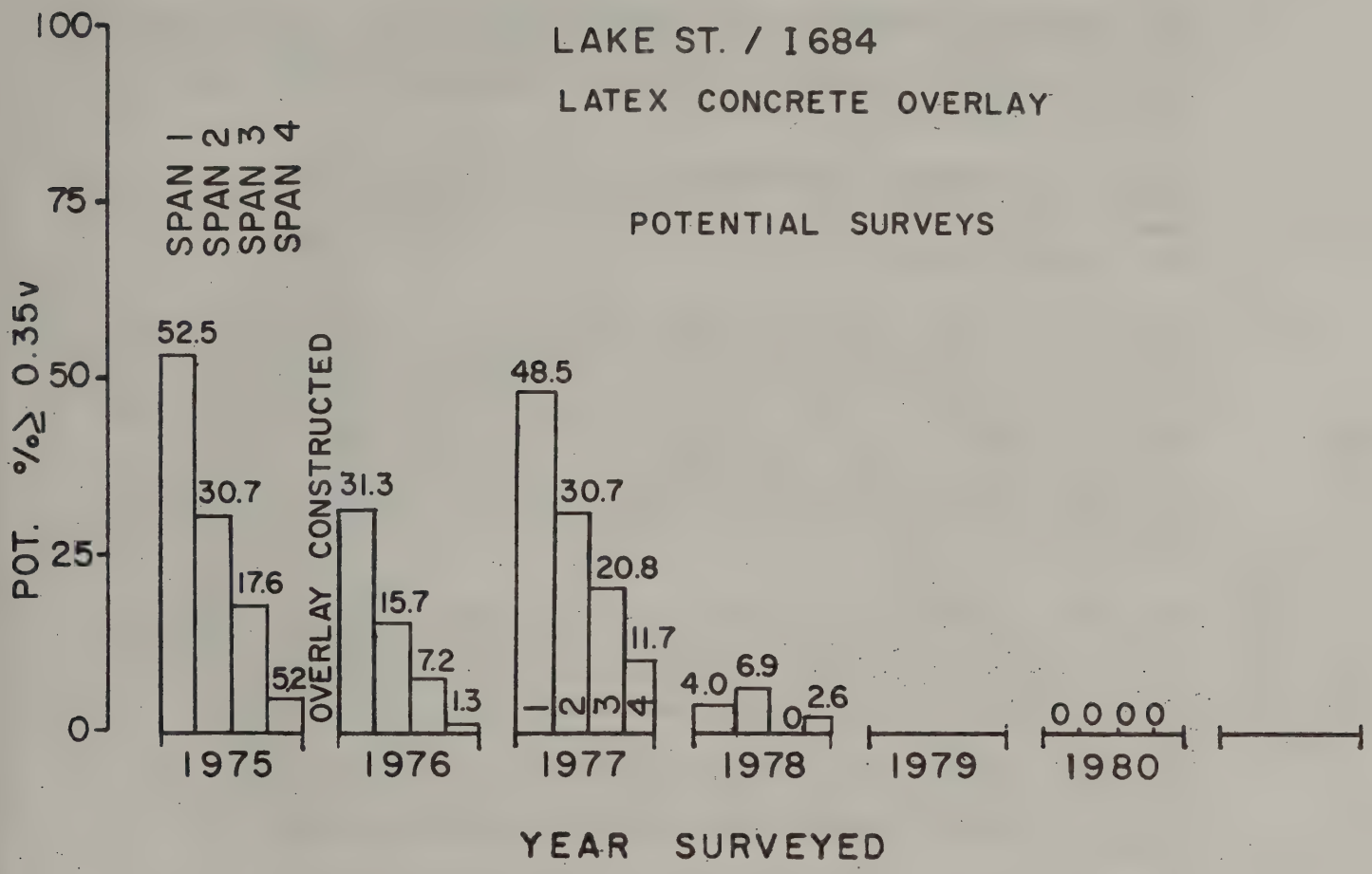
This structure was overlaid with Latex Modified Concrete in 1976. The overlay was placed full width of the deck after surface preparation and deep removal of concrete around rebars which exhibited active corrosion. Traffic was detoured around this structure during construction.

In Figure 2 the percentage of potential values greater than 0.35v are plotted for each span of this structure. The 1975 data shows the initial high values of active corrosion associated with the reinforcing steel and associated concrete spalling in the original concrete deck.

After overlay construction, potentials were again surveyed. The data showed a decrease in percentage of active corrosion, but still significant amounts in spans 1 and 2. Another survey in 1977 showed an increase in active corrosion in all spans but a delamination survey done using a chain drag revealed no delaminations. Subsequent potential surveys in 1978 and 1980 showed active corrosion had dropped to low values and then to nothing. Surveys performed in 1978 and 1980 showed no delaminations.

Moisture and oxygen sealed in the deck by the impermeable overlay may be responsible for the initial high values of active corrosion noted in 1976 and 1977. It appears that active corrosion later ceased due to moisture in the deck evaporating, probably through the deck underside. Based on the potential data and delamination surveys, some corrosion did occur after construction, but was not severe enough to cause expansive corrosion and delamination and eventual spalling of the overlaid deck.

FIGURE 2



		1975	1976	1977	1978	1979	1980
Span 1	n	99	99	99	101	N	100
	avg.	.36	.31	.35	.23	O	.12
	S.D.	.11	.06	.06	.06		.06
Span 2	n	127	127	127	130	S	127
	avg.	.29	.26	.31	.24	U	.12
	S.D.	.13	.08	.07	.06	R	.06
						V	
Span 3	n	125	125	125	127	E	125
	avg.	.26	.25	.30	.19	Y	.12
	S.D.	.10	.07	.06	.05		.05
Span 4	n	77	77	77	76		76
	avg.	.19	.20	.28	.20		.12
	S.D.	.08	.06	.06	.06		.05

ROUTE 20 OVER 18 MILE CREEK, ERIE COUNTY, REGION 5
CONTRACT NUMBER D95157, BIN 1015450, SEVEN SPANS

Spans 5 and 7, total area 9,184 square feet, were chosen to represent the structure for this evaluation

This structure was overlaid with Latex Modified Concrete. The westbound lanes were overlaid in the fall of 1976 while the eastbound lanes were overlaid in the spring of 1977. Traffic was maintained on half the structure during overlay construction.

Potential, visual and delamination surveys were conducted before and at intervals after construction. The results of the potential surveys are shown in Figure 3. Extensive areas of active corrosion existed in spans 5 and 7 before construction.

A potential survey, six months after completion of construction, showed a decrease in active corrosion. Visual observations and delamination surveys at this time showed the longitudinal construction joint had separated. This is the same style butt type joint which had separated on other structures. Some short, 6 to 18 inch long cracks, were noted perpendicular to the longitudinal construction joint and at the transverse joints. Some wider longitudinal and transverse cracks were seen in the middle of some spans. Many transverse joints have hollow sounding delaminated areas on each side of the joint.

The "wider" cracks in the overlay are due to existing cracks reflecting through the overlay. The short length tight cracks may be due to excess water in the latex concrete mixture which showed up as shrinkage cracks. The separation and cracks will be observed for their future effect.

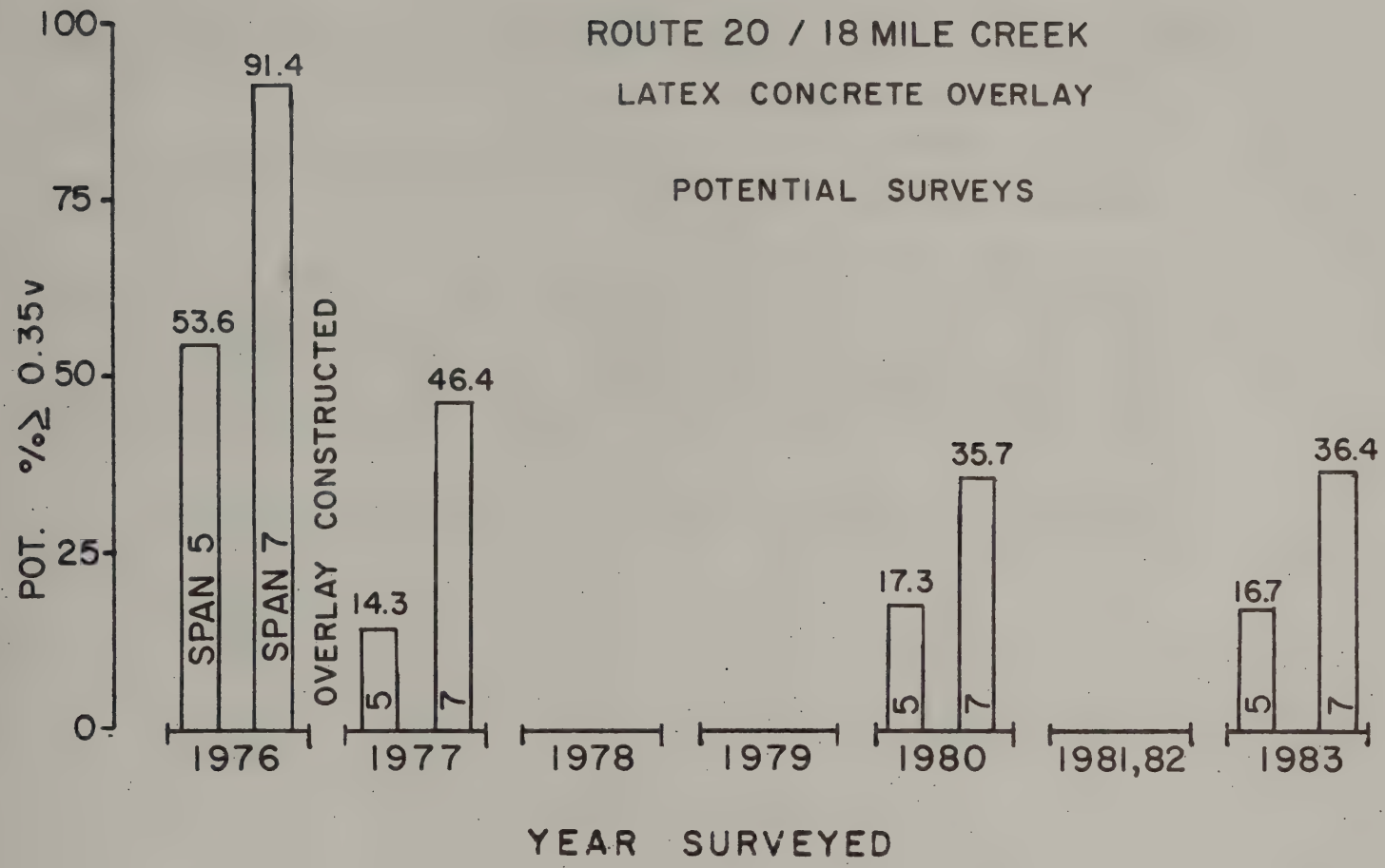
The hollow sounding areas indicate delaminated areas of the overlay and since they occurred so soon after construction appear to be related to surface preparation and bond rather than environment and material performance.

In 1980 and 1983, potential surveys showed similar percentages of active corrosion as those seen after construction in 1977. The same areas of the west lane, in span 5, that showed active corrosion in 1977 also show active corrosion in 1980.

In span 7, the active corrosion areas of 1977 and 1980 coincide near the north joint. Other areas of span 7 no longer show active corrosion.

The areas of greatest concern are spalled areas which have occurred at the north joints of both spans. These areas coincide with areas of active corrosion and the hollow areas found in 1977.

FIGURE 3



		1976	1977	1978	1979	1980	1981,82	1983
Span 5	n	250	300	No	No	280	No	275
	avg.	.36	.28	S	S	.28	S	.28
	S.D.	.09	.07	U	U	.07	U	.08
				R	R		R	
Span 7	n	70	84	V	V	84	V	77
	avg.	.45	.33	E	E	.31	E	.32
	S.D.	.07	.09	Y	Y	.09	Y	.08

NORTH GENESEE STREET OVER THE MOHAWK RIVER BARGE CANAL, ONEIDA COUNTY, REGION 2,CONTRACT NUMBER D95178, BIN 1051720, THREE SPANS

Span 1 which has an area of 6,552 Square Feet is being evaluated.

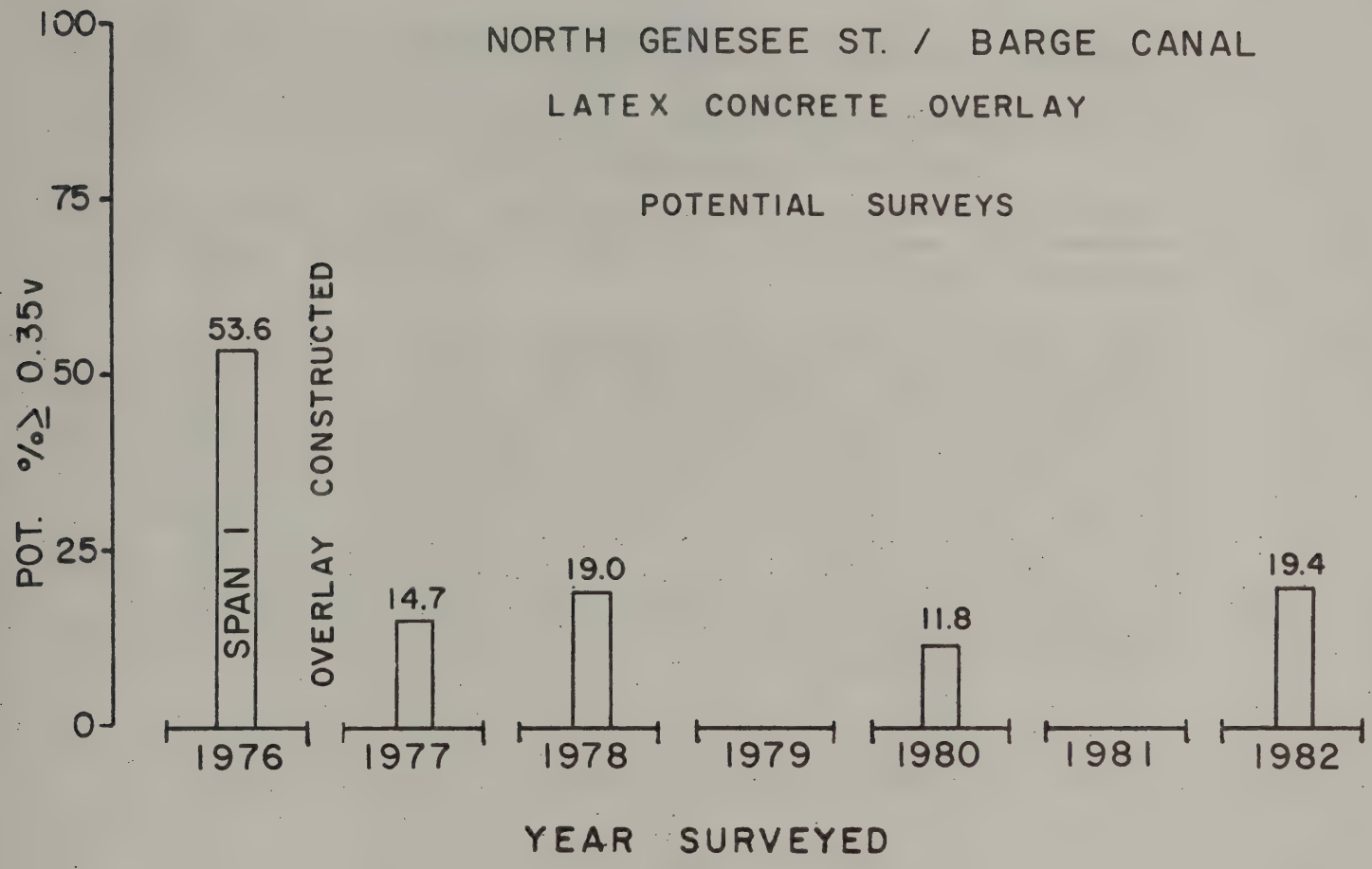
This structure was overlaid with Latex Modified Concrete in 1976. The overlay was first placed on the southbound lanes while traffic was maintained on the northbound lanes. Traffic was diverted onto the cured lanes while the remaining lanes were prepared and overlaid.

Potential, delamination and visual surveys were conducted before and at intervals after construction. The results of the potential surveys are presented in Figure 4.

High percentages of active corrosion existed before concrete removal, surface preparation, and overlay placement. After construction it was found that areas of active corrosion decreased. It was observed that the longitudinal construction joints had separated after construction. This is similar to the separation of other "butt" type joints. Some of the areas of active corrosion are associated with leakage at this separated joint. Other areas of active corrosion are near the transverse joints.

No cracks, delaminations or spalls were noted in this Latex Modified Concrete overlay in the 1982 survey.

FIGURE 4



		1976	1977	1978	1979	1980	1981	1982
Span 1	n	302	300	300	No	246	No	273
	avg	.35	.28	.28	S	.25	S	.27
	S.D.	.08	.06	.06	U	.07	U	.08
					R		R	
					V		V	
					E		E	
					Y		Y	

NORTH GENESEE STREET OVER REALL CREEK, ONEIDA COUNTY, REGION 2
CONTRACT NUMBER D95178 BIN 1051730, SINGLE SPAN

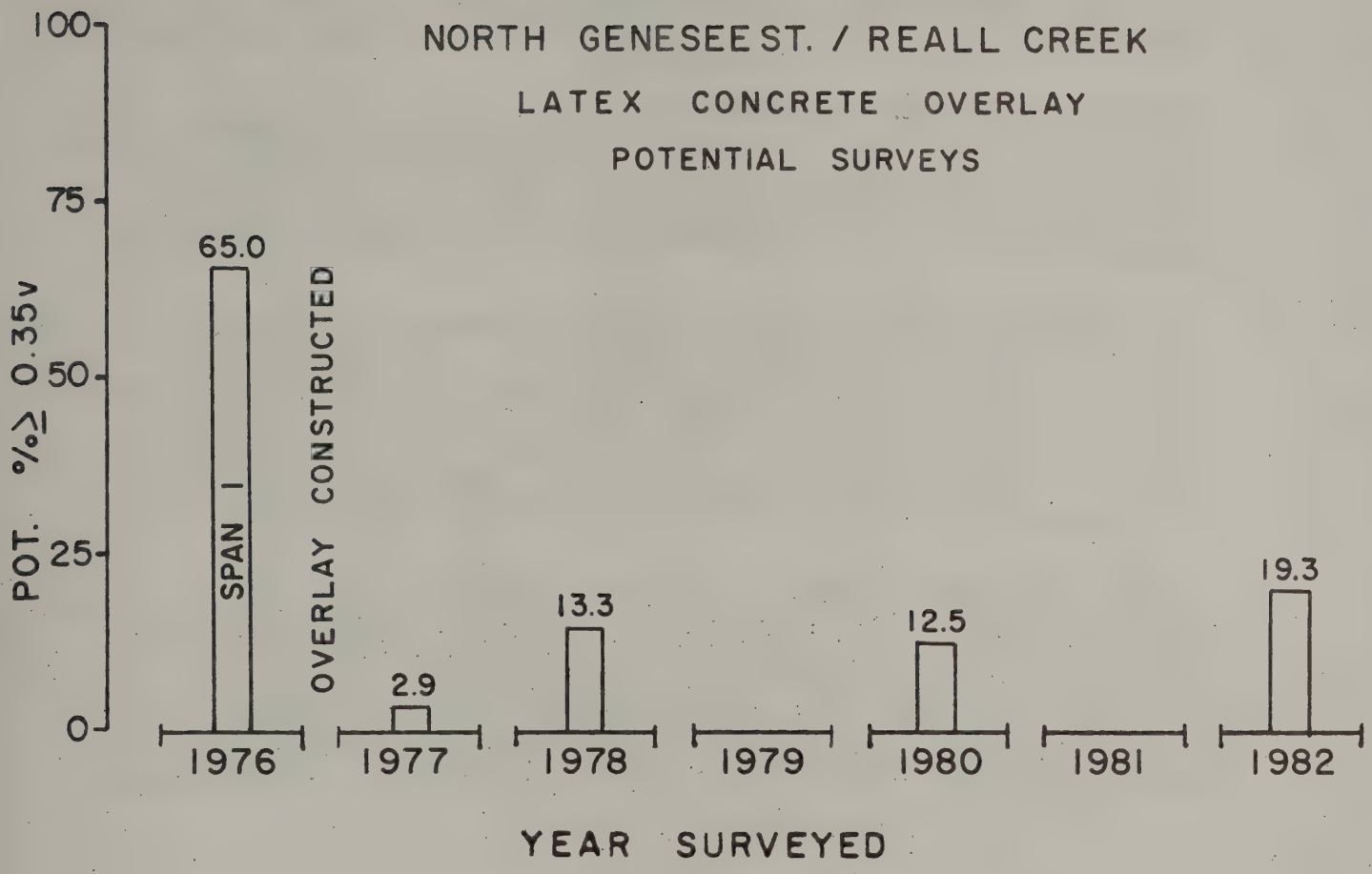
Total deck area 2,288 square feet is being evaluated.

This structure was overlaid with Latex Modified Concrete in 1976. The overlay was placed on the southbound lanes June 10, 1976 while traffic was maintained on the northbound lanes. Traffic was diverted onto the cured lanes while the remaining lanes were prepared and then overlaid on August 4, 1976. The butt type construction joint was used.

Potential, delamination and visual surveys were conducted before and at intervals after construction. The results of the potential surveys are presented in Figure 5.

Figure 5 shows the initial high percentage of active corrosion before construction in 1976 and the low percentage of active corrosion after construction in 1977. In 1978 corrosion potentials increased. A few cracks were observed in the northbound area of the deck. In 1980 the cracks in the northbound driving lane were hairline and confined to the extreme east end. By the 1982 potential survey, the cracks had become more pronounced and the delamination survey showed that the area near the cracks were debonded. Cores were taken to determine the extent of the delaminated concrete. The cores demonstrated that the overlay had not debonded but that not enough of the original concrete had been removed and corrosion of the resteel had progressed until that area of the bridge deck concrete cracked and debonded from the reinforcing steel.

FIGURE 5



		1976	1977	1978	1979	1980	1981	1982
Span 1	n	120	102	105	No	88	No	88
	avg.	.38	.27	.25	S	.22	S	.26
	S.D.	.10	.05	.08	U	.10	U	.10
					R		R	
					V		V	
					E		E	
					Y		Y	

RTE. 378 EASTBOUND OVER BROADWAY, ALBANY COUNTY, REGION 1
CONTRACT NUMBER D95757, BIN 1052950, SINGLE SPAN

Total deck area 6,855 square feet is being evaluated.

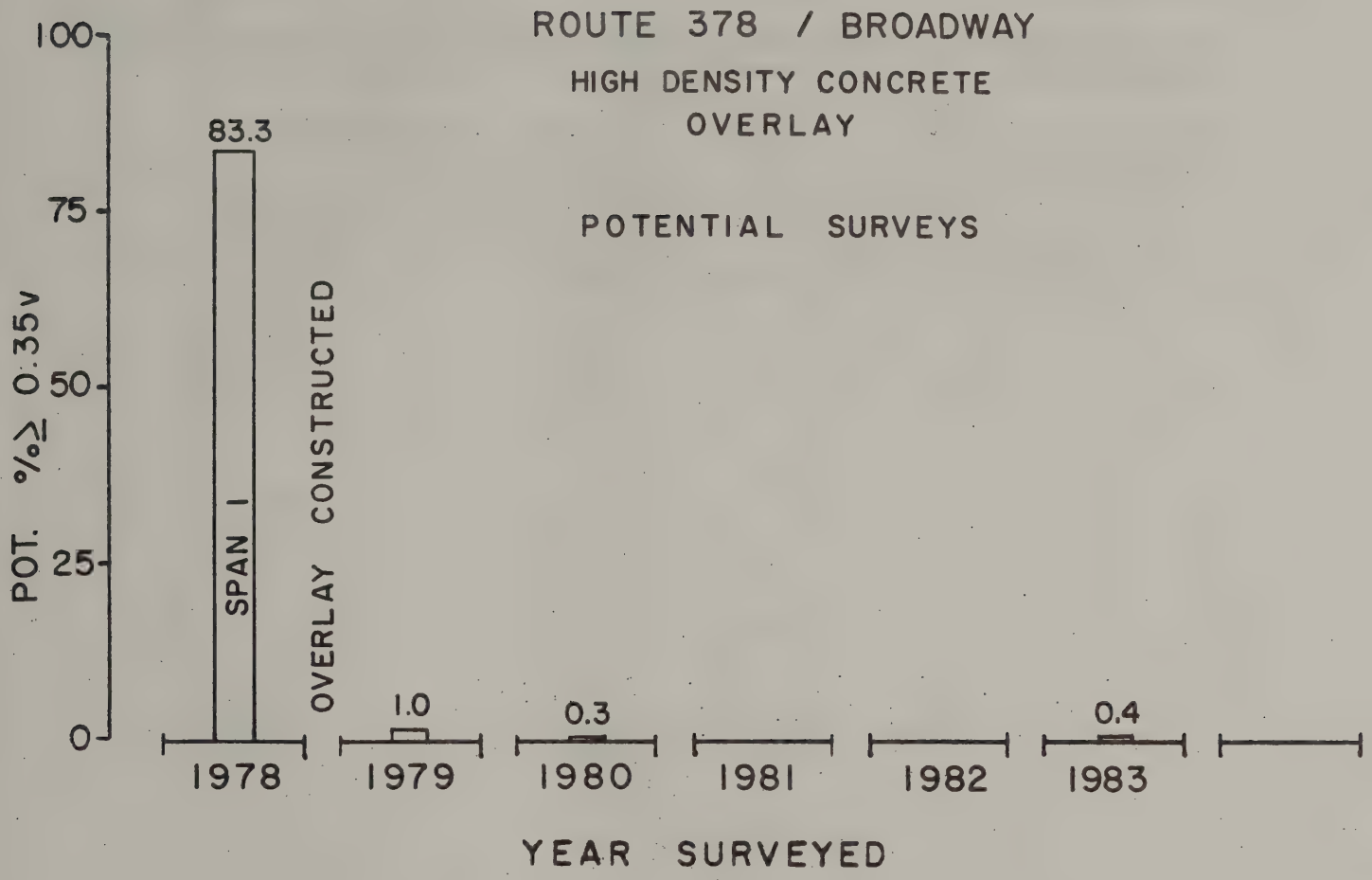
This structure was overlaid with High Density Concrete in 1978. The overlay was placed on half the width of the bridge while traffic was maintained on the other half.

Potential values greater than 0.35v were found before construction in the majority of the deck area. Potential data is presented in Figure 6. Due to the spalling and large area of active corrosion, the entire surface was removed and concrete excavated to one inch under the top rebar mat. This resulted in the top rebar mat being encased and covered with high density concrete.

The longitudinal construction joint between placements was constructed differently than the butt joint used previously. The edge of the new overlay is sawcut 3/4 ± 1/8 inch deep longitudinally, the remaining depth of overlay is chipped to form a 45 degree bevel. Mortar grout is applied before the adjacent overlay is placed. The additional surface area due to the chipping and beveling has provided a water tight joint that does not separate. The "beveled" type construction joint was specified in this and for future projects.

Potential data taken in 1980 and 1983 shows only 0.3 percent and 0.4 percent of the readings respectively are greater than 0.35v. This is due to one potential reading in each survey which occurred near an armored transverse joint. This reading is suspect, since it probably is measuring corrosion of the steel armor angle rather than the top rebar mat. The 1980 and 1983 data shows that no areas of active corrosion exist over the deck area including the longitudinal construction joint. No hollow areas were found during the delamination survey.

FIGURE 6



		1978	1979	1980	1981	1982	1983
Span 1	n	282	No	287	No		265
	avg.	.44	S	.16	Survey		.17
	S.D.	.09	U	.04			.07
			R				
			V				
			E				
			Y				

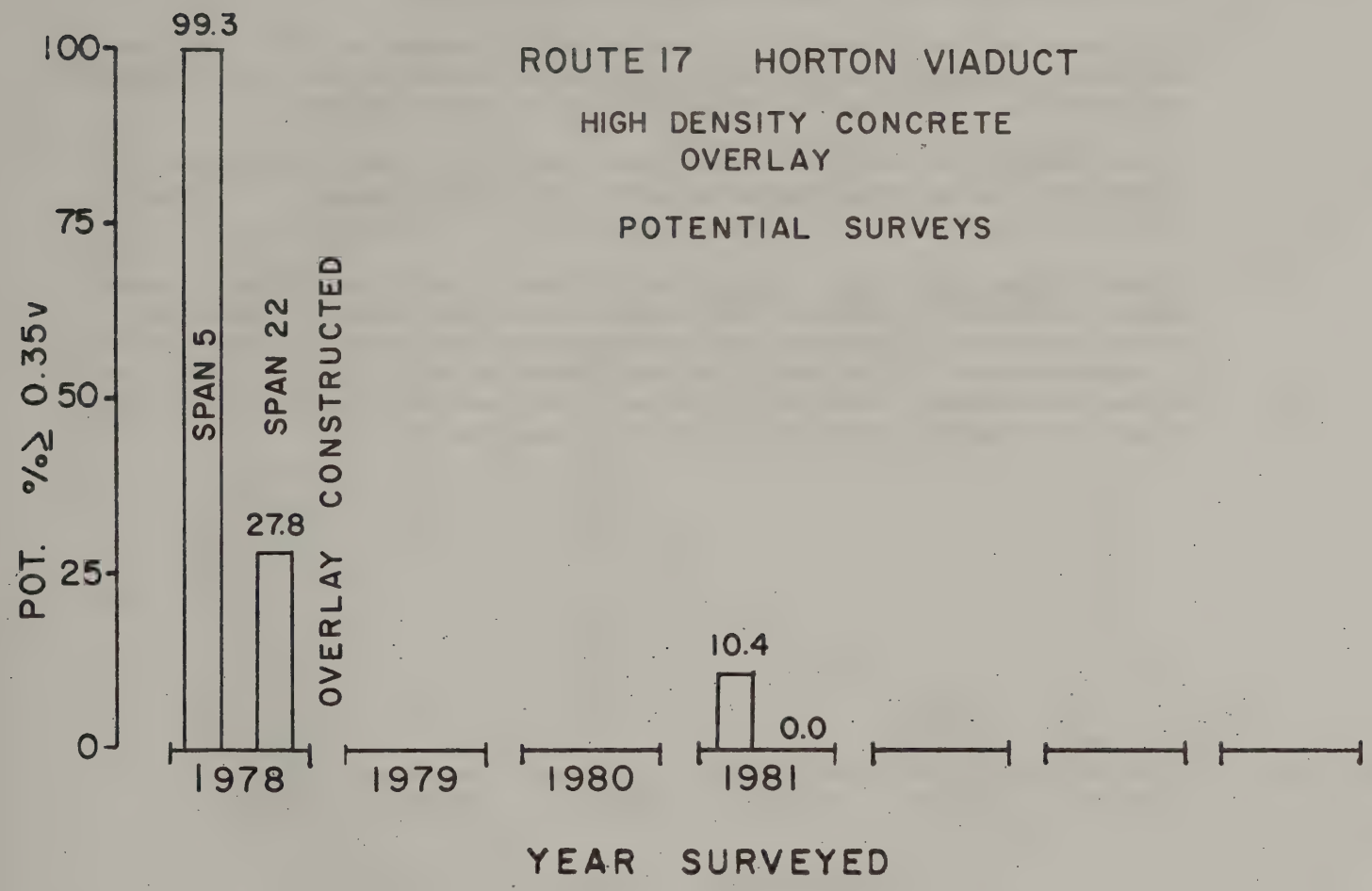
HORTON VIADUCT, ON RTE 17, DELAWARE COUNTY, REGION 9
CONTRACT NUMBER D95779, BIN 1054939, TWENTY FOUR SPANS

Spans 5 and 22, Eastbound, total area 6,726 square feet, were chosen to represent the structure for this evaluation.

This structure was overlaid with High Density Concrete beginning in 1978 and continuing into 1979. The beveled type construction joint was used.

Potential, delamination and visual surveys were conducted before construction and in October 1981 and are presented in Figure 7. Span 5 in 1981 exhibited no surface defects while span 22 showed only surface mapcracking. Figure 7 shows the high percentage of corrosion before construction of the High Density Concrete overlay in 1978-79 and the very low percentage of active corrosion in 1981.

FIGURE 7



		1978	1979	1980	1981
Span 5	n	144	NO		144
	avg.	.53	S		.29
	S.D.	.08	U		.05
			R		
Span 22	n	36*	V		120
	avg.	.25	E		.22
	S.D.	.12	Y		.05

*Note: 70% of span 22 was overlaid with asphalt concrete due to spalling deterioration, potential measurements were only possible on the uncovered concrete deck.

ROUTE 15 SOUTHBOUND, OVER CONRAIL, STEUBEN COUNTY, REGION 6
CONTRACT NUMBER D96091, BIN 1054561, THREE SPANS

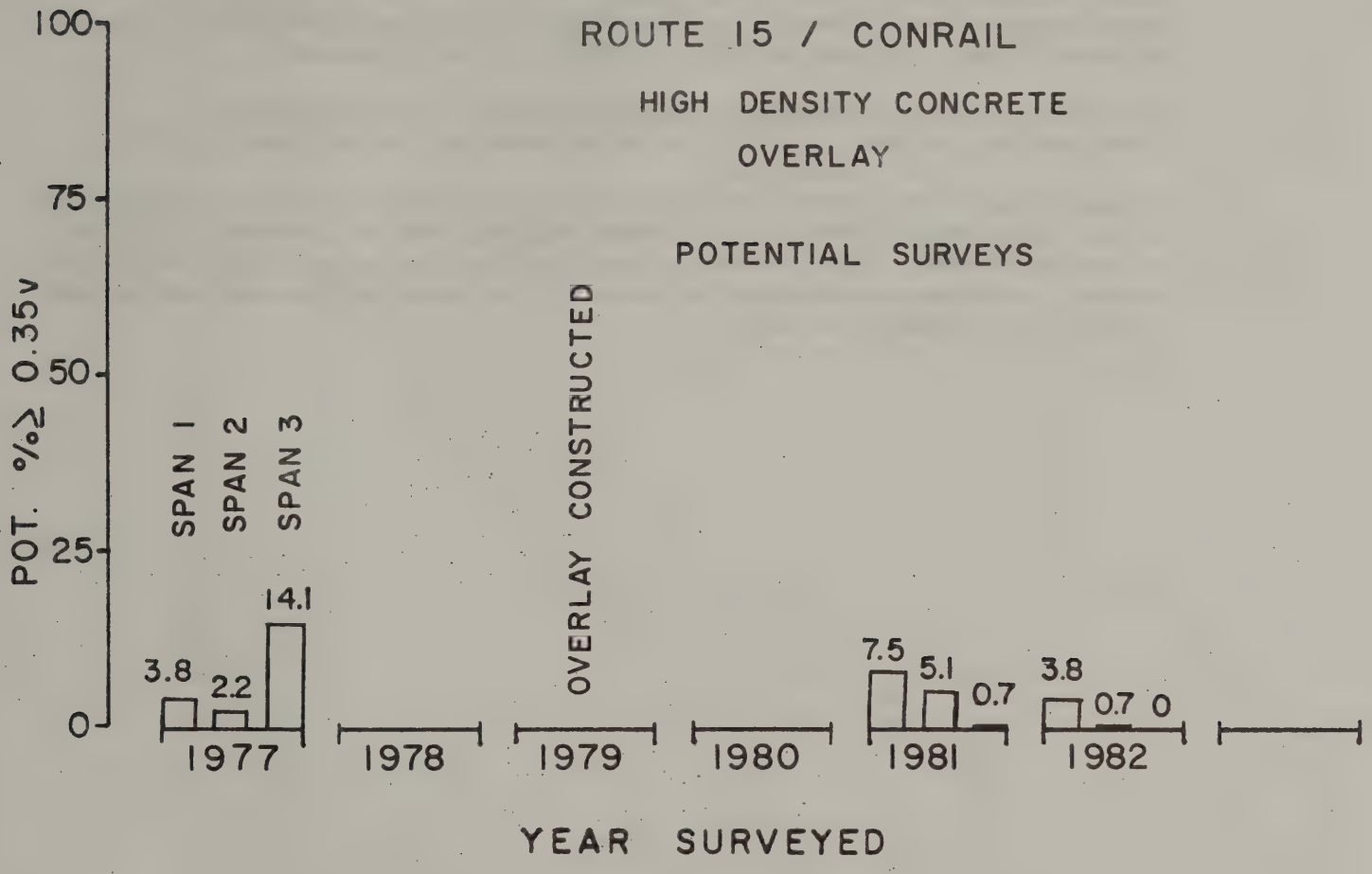
Total deck area 10,036 square feet is being evaluated.

This structure was overlaid with High Density Concrete in 1979. The overlay was placed on half the width of the bridge while traffic was maintained on the other half. The beveled type construction joint was used.

Visual examination and the overall condition of the deck surface were the determining factors for overlaying with high density concrete. Potential, delamination and visual surveys were conducted at the time of construction.

Figure 8 shows the initial low values in spans 1 and 2 and higher in span 3. During construction concrete was removed around the resteel in areas of active corrosion. These deep concrete removal areas were the least in span 1, approximately 30% in span 2 and approximately 50% in span 3. The areas of concrete removal were less in spans 1 and 2 and this may account for the slight increase in corrosion values after construction.

FIGURE 8



		1977	1978	1979	1980	1981	1982
Span 1	n	133				134	133
	avg.	.21		N O S U R V E Y		.22	.19
	S.D.	.06				.09	.09
Span 2	n	136				136	137
	avg.	.22				.19	.16
	S.D.	.06				.10	.08
Span 3	n	142				142	142
	avg.	.22				.17	.13
	S.D.	.09				.07	.05

ROUTE 222 OVER FALL CREEK, TOMPKINS COUNTY, REGION 3
CONTRACT NUMBER D96122, BIN 1041820, TWO SPANS

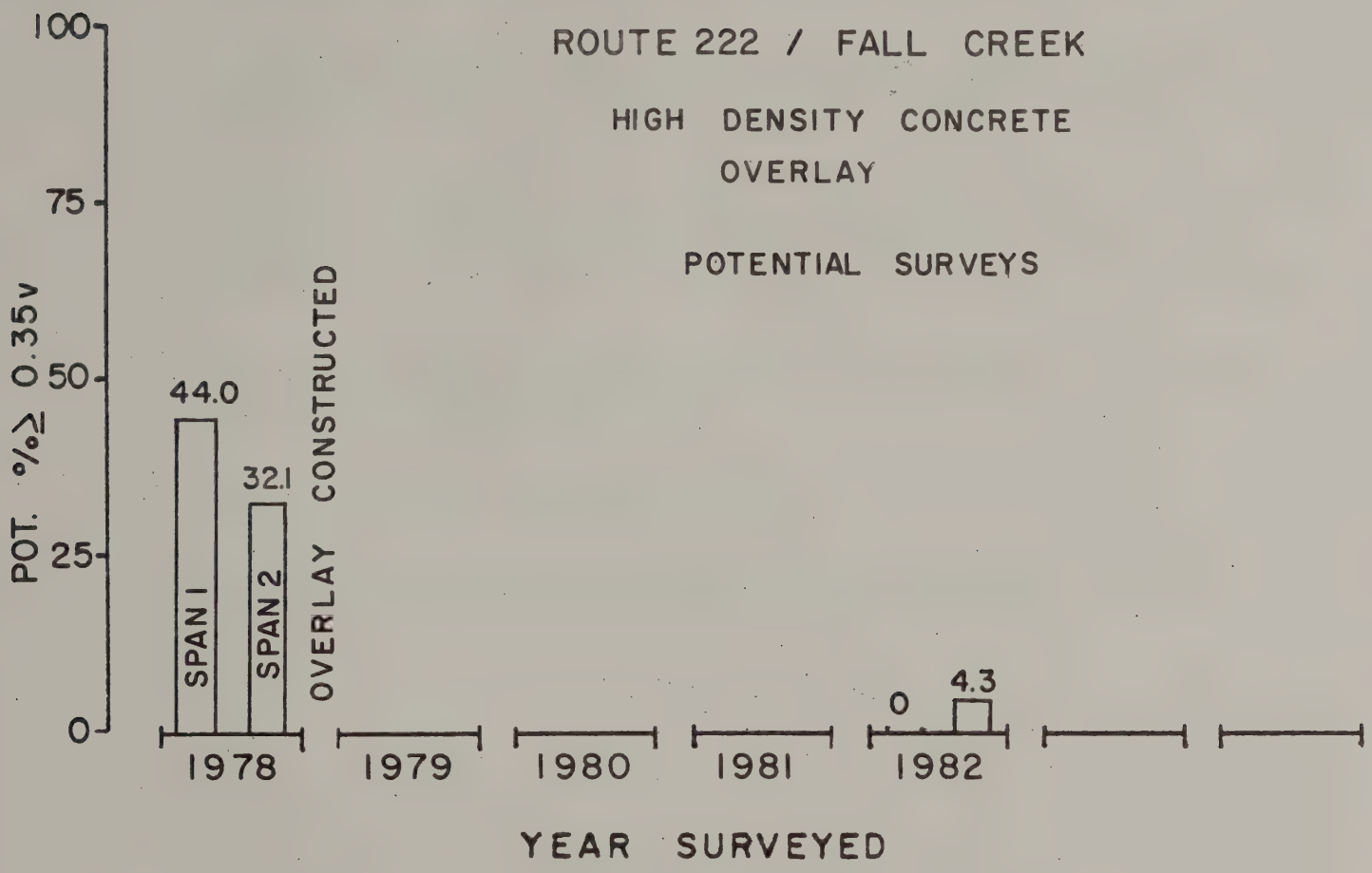
Total deck area 4,240 square feet is being evaluated.

This structure was overlaid with High Density Concrete in 1979-80. The overlay was placed a lane at a time while traffic was maintained on the adjacent lane. The beveled type construction joint was used.

Potential, delamination and visual surveys were conducted before construction, on June 14, 1978 and after construction on June 9, 1982.

Figure 9 shows the initial high percentage of corrosion before construction of the high density overlay in 1979-80 and the very low percent of active corrosion in 1982. Span 1 and 2 show no surface defects in the 1982 survey except a hairline crack where the edge of the existing drainage grates were filled with overlay concrete.

FIGURE 9



		1978	1979	1980	1981	1982
Span 1	n	84	NO SURVEY			90
	avg.	.30				.20
	S.D.	.13				.04
Span 2	n	84				92
	avg.	.28				.24
	S.D.	.10				.06

CONCLUSIONS

1. Concrete bridge deck spalling caused by reinforcing steel corrosion and expansion has been corrected by installing a High Density or Latex Modified Concrete overlay.

2. Potential readings taken after construction show a marked decrease or elimination of active corrosion in the top mat reinforcing steel. The oldest bridge deck overlay has experienced seven winters of service.

3. Butt type overlay construction joints have separated and are a source of leakage and active corrosion. The shallow saw cut and chipped bevel construction joint, which replaced the butt joint when the problem was recognized, has not separated, and is not a source of leakage or active corrosion.

4. Cracks which are the full depth of the overlay are a source of leakage and active corrosion. In one case, an area of shrinkage cracking has caused corrosion and delamination.

5. Overlay delaminations that have been found are a small percentage (0.2%) of the total area being surveyed.

6. Surveys should be continued with more frequent (annual) observations made where active corrosion and/or delaminations have been found.

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